

Oct. 8, 1963

H. JANSEN ETAL
GAS SAFETY DEVICE

3,106,239

Filed March 29, 1960

6 Sheets-Sheet 1

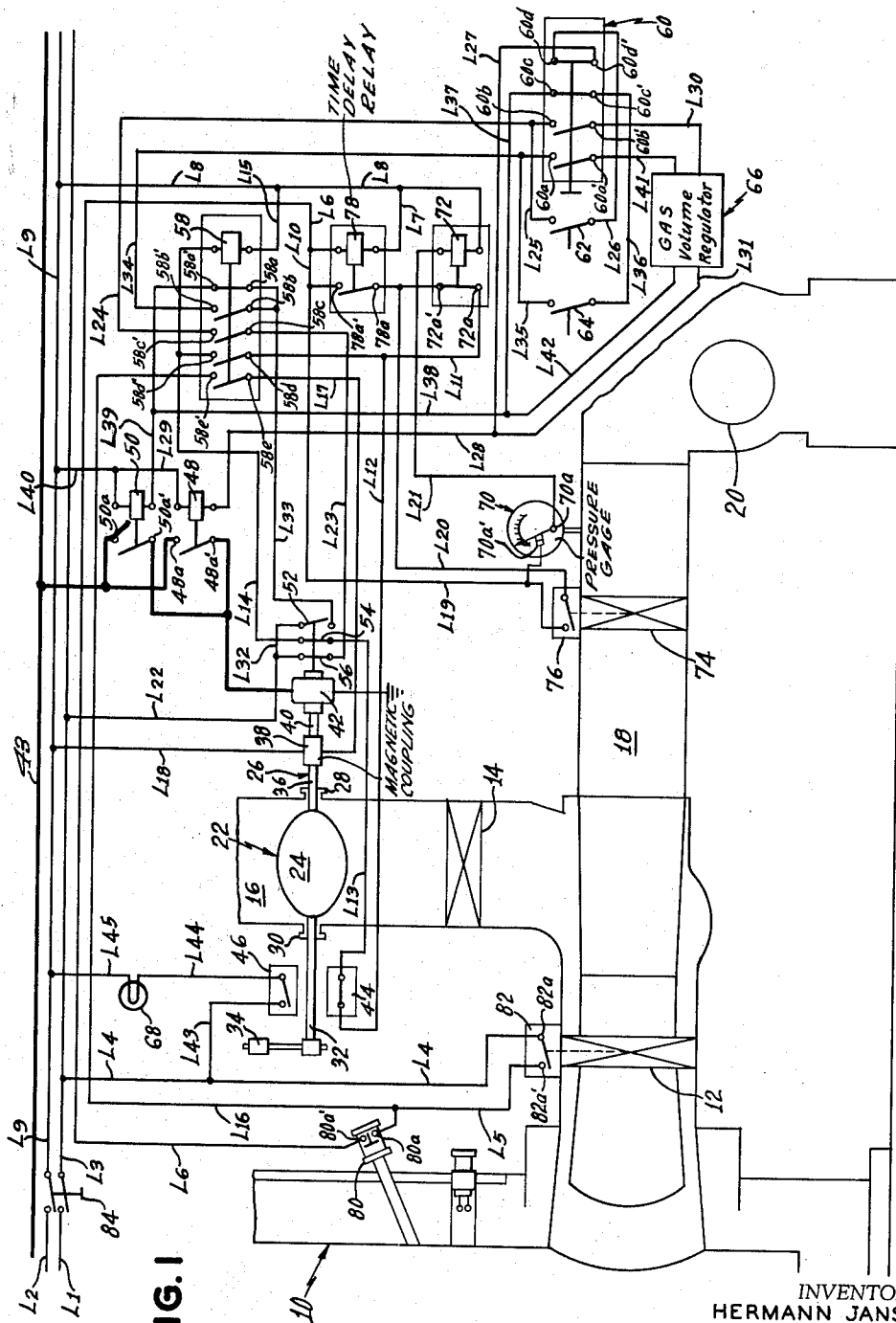


FIG. 1

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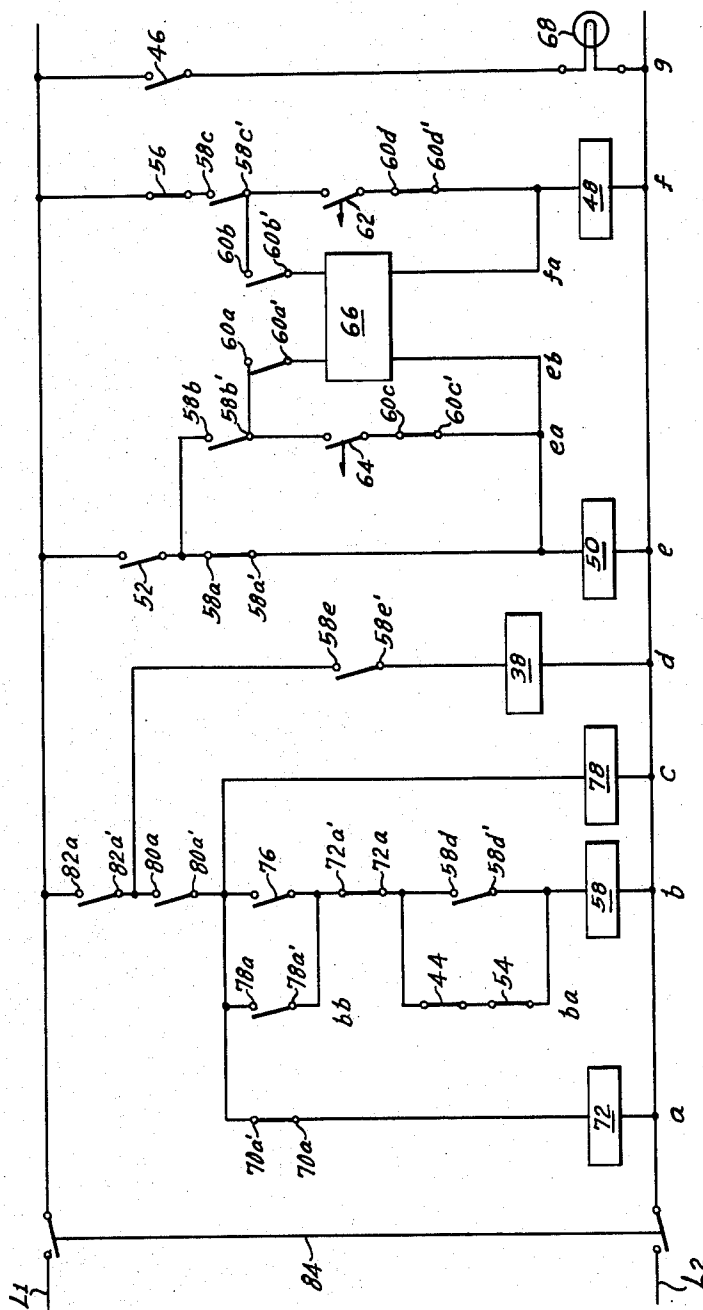
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FIG. 2



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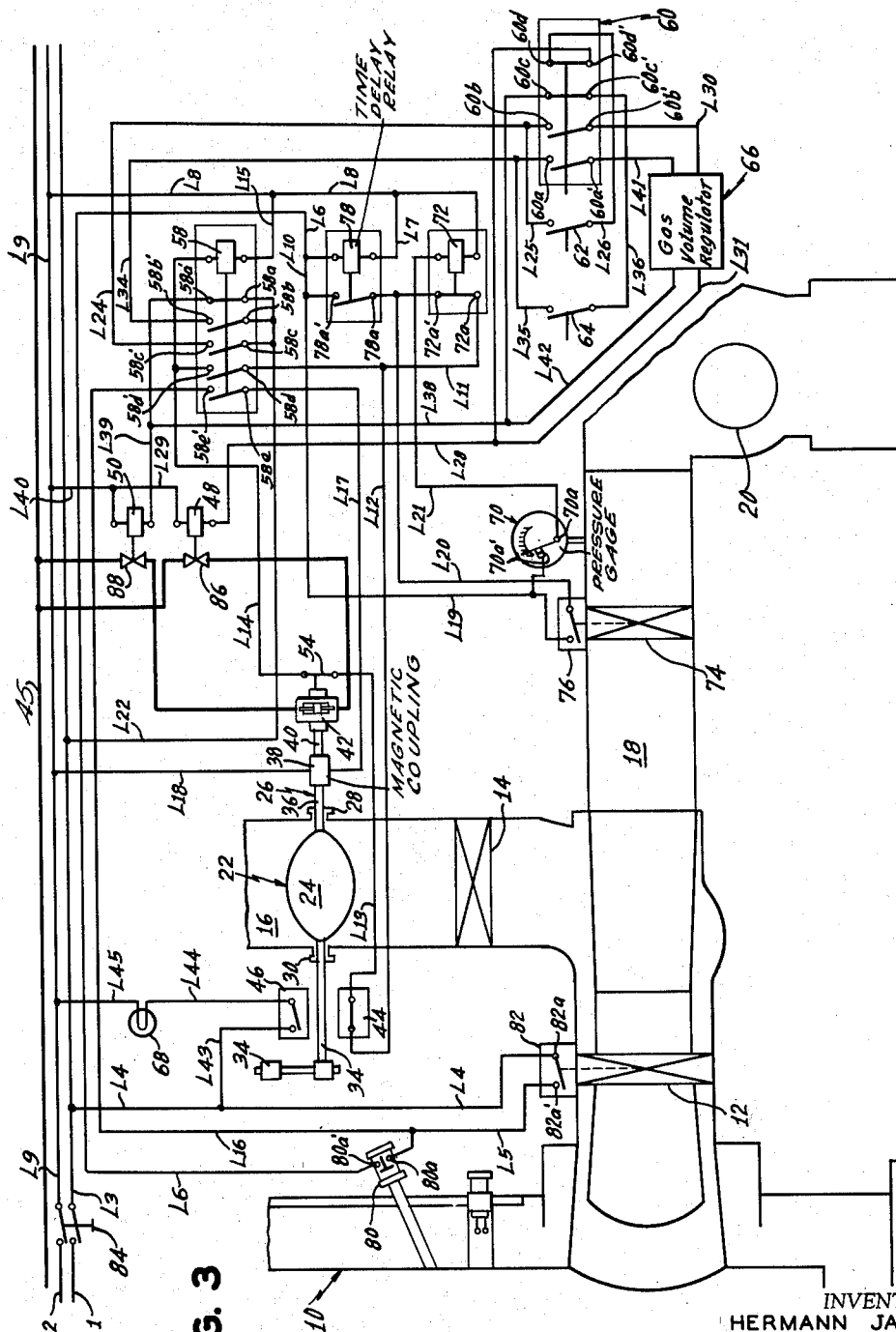


FIG. 3

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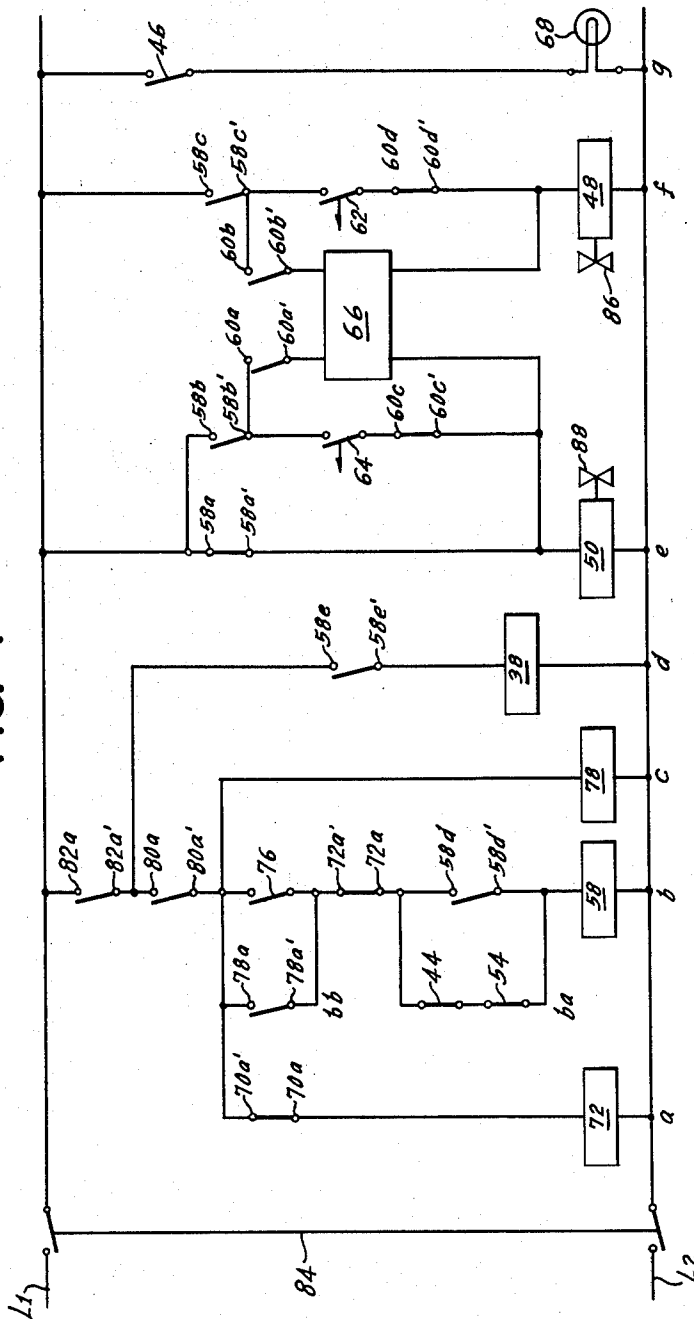
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GAS SAFETY DEVICE

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FIG. 4



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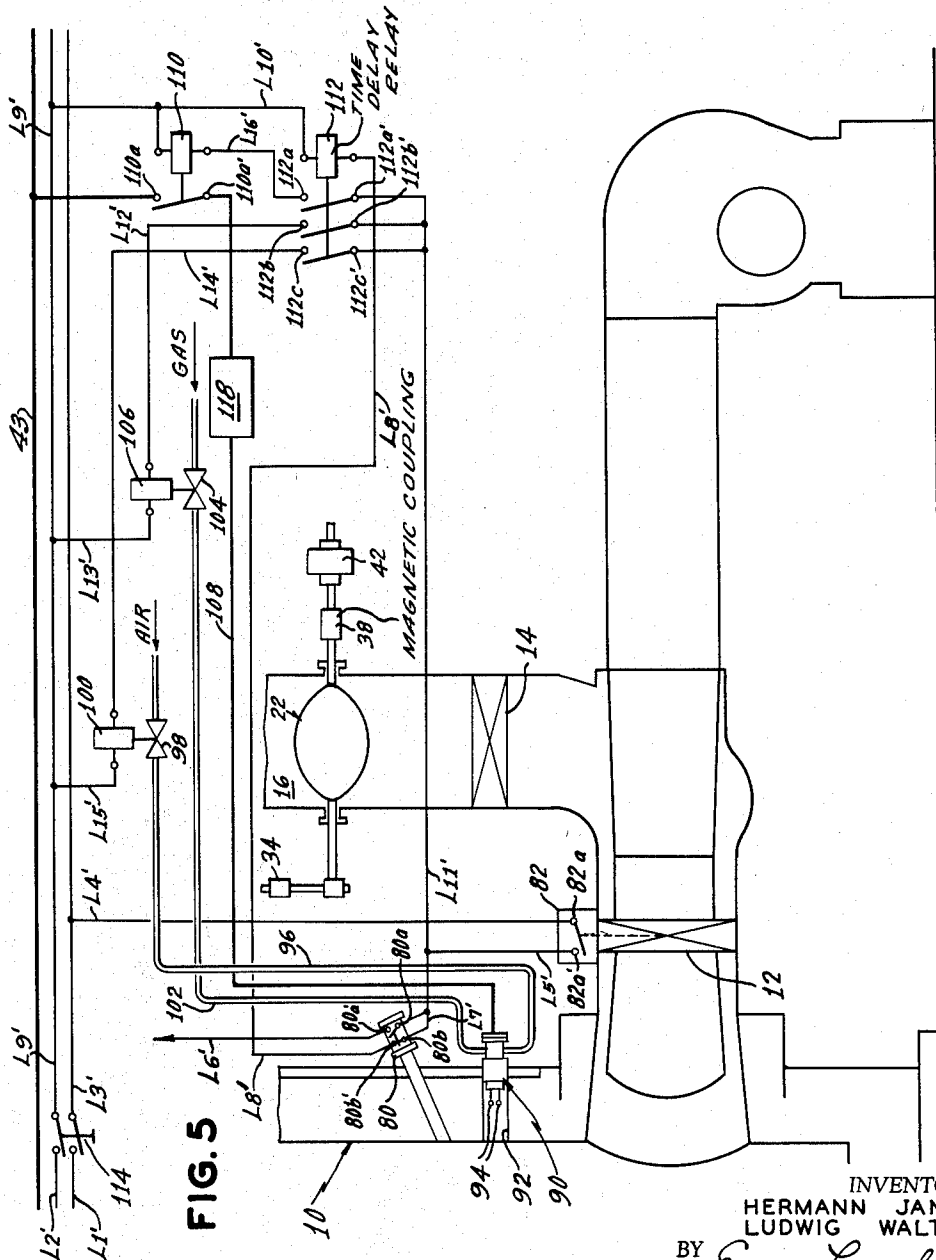
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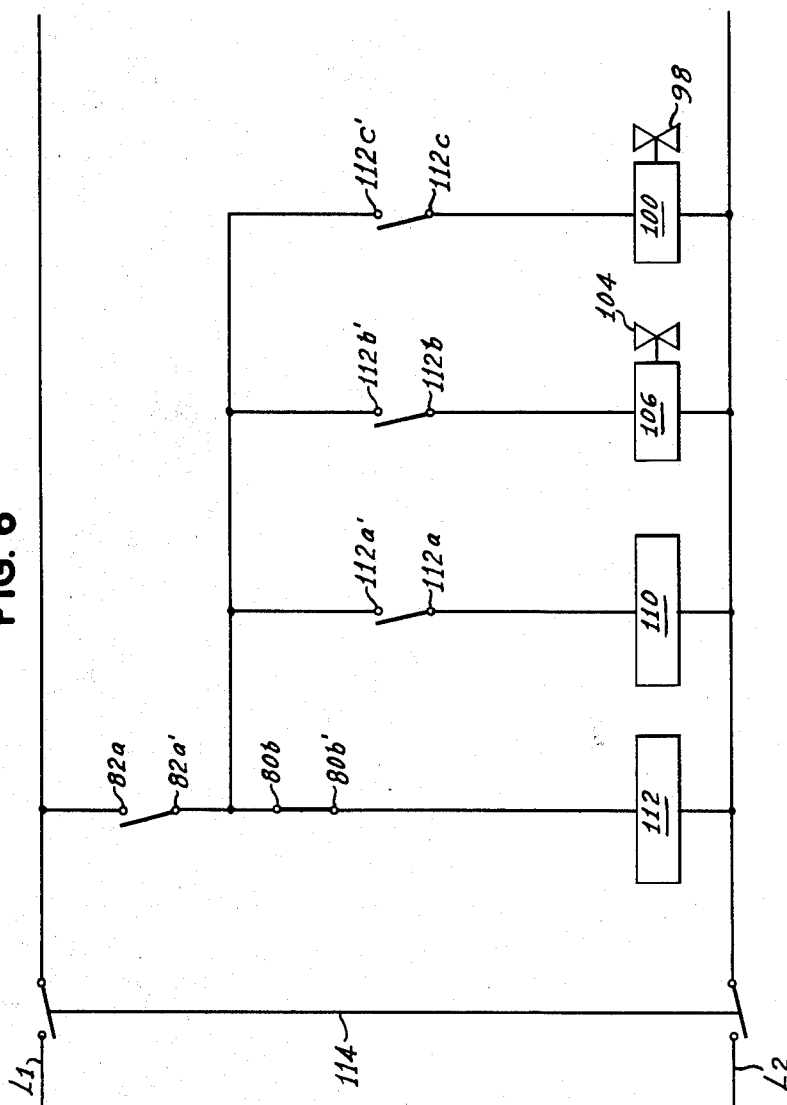
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GAS SAFETY DEVICE

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FIG. 6



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GAS SAFETY DEVICE

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14 Claims. (Cl. 158—123)

The present invention relates generally to improved gas safety means for hot blast stoves.

During the heating cycle of a hot blast stove, when it is in the "On Gas" condition, gas and air are burned in the combustion chamber. The gas and the air are separately fed to the hot blast stove through the burner. A control element such as a butterfly valve or the like is usually placed in the gas downtake conduit to permit the desired amount of gas to be admitted to the hot blast stove. The air is introduced by means of a mover, preferably a centrifuge, such as a blower or a fan, with the quantity of air introduced being determined by means of a ratio controller. During the operation of the stove, the operation of the blower may be interrupted, due to mechanical failure or due to power failure, and such breakdown of the mover will immediately interrupt the intake of air into the burner. Under such circumstances, the hot blast stove receives only gas which can result in serious explosions causing injury to life, limb and apparatus.

In order to overcome this serious danger, it has been the practice to interpose a gas safety device in the gas down-take conduit ahead of the butterfly valve which regulates the admission of gas, and to provide means for automatically closing such gas safety device when the air intake is interrupted for any reason whatsoever. A safety device of this type is fully described in application Serial No. 774,690, filed November 18, 1958, now U.S. Patent No. 3,039,522, issued June 19, 1962, and assigned to the assignee hereof.

The present invention is an improvement of the safety devices described in the two above identified co-pending applications. More specifically, according to the present invention, the gas regulating butterfly valve and the gas safety valve which have previously been two separate elements, have now been combined into a single valve or element which performs both the safety function and the regulating function, in an improved and more satisfactory manner and at a substantially reduced cost.

It is therefore a primary object of the present invention to provide novel and improved gas safety means which will automatically close to interrupt the feeding of gas into the stove, in direct response to an interruption in the satisfactory intake of air.

Another object is the provision of a single valve which combines the features of regulating the gas supply and of defining a safety device whereby said valve is automatically closed in direct response to a power failure or to the interruption of air intake.

Another object is the provision of a combination gas safety device and gas regulating device which will automatically close in response to power failure or interruption of air intake, and which valve cannot be reopened until any failure of the system has been corrected and the system has been restored to working condition.

Another object of the present invention is the provision, in a combination gas safety device and gas regulating device, of means which will prevent the operation of the latter unless the combustion chamber temperature of the stove is above a predetermined value.

Another object of the invention is the provision of auxiliary ignition burner means for heating the combustion chamber if the latter is insufficiently heated at the time a stove is placed in the "On Gas" condition.

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The above and other objects, features and advantages of the present invention will be more fully understood from the following description considered in connection with the accompanying illustrative drawings.

In the drawings:

FIG. 1 is a schematic representation of a gas safety device in accordance with the invention;

FIG. 2 is a schematic drawing of the circuitry of FIG. 1, but arranged differently from FIG. 1 for purposes of explanation;

FIG. 3 is a schematic representation similar to FIG. 1, and showing a slight modification thereof;

FIG. 4 is a schematic drawing of the circuitry of FIG. 3, but arranged differently from FIG. 2 for purposes of explanation;

FIG. 5 is a schematic representation of an auxiliary burner safety device in accordance with the invention, which may be used in conjunction with the systems of FIG. 1 or FIG. 3; and

FIG. 6 is a schematic drawing of the circuitry of FIG. 5, but arranged differently from FIG. 5 for purposes of explanation.

Referring now to the drawings and specifically to FIG. 1, there is shown a hot blast stove 10 which is adapted to be heated so that it may subsequently have a blast of cold air passed therethrough which will be heated so as to supply hot blast to a blast furnace. The hot blast stove 10 is provided with a burner shut-off valve 12 and a gas shut-off valve 14. The gas and the air which form the gas-air mixture to be burned in the combustion chamber are fed separately to the hot blast stove through the burner. The gas is fed through a gas downtake conduit 16 and the air is fed through the air main 18 by means of a prime mover such as a fan or blower 20. In the gas downtake 16 there is provided the combination gas regulating and safety butterfly valve 22. Combination gas regulating and safety valve 22 comprises a valve disc proper 24 which is fixed to a shaft 26 mounted for pivotal movement in gas downtake 16, in any suitable way, such as in bearings 28 and 30. Shaft 26 is provided at end 32 thereof (the left end viewing FIG. 1) with a counter-weight 34. The other end 36 of shaft 26 is adapted to be physically connected, through a magnetic coupling such as a magnetic clutch 38, to a shaft 40 of a drive unit 42. When the magnetic coupling or clutch 38 is energized, the coupling 38 physically connects shaft 26 to shaft 40 so that the drive unit 42 is operative to impart rotational movement to shaft 26 and thus to valve disc 24, in order to rotate the latter to a desired position. When magnetic coupling 38 is de-energized, end 40 of shaft 26 becomes unconstrained, and due to the counter-weight 34 and the mass of valve disc 24, the valve disc is automatically gravitationally biased into a closed position thereof. Accordingly, whenever coupling 38 is de-energized, the valve 22 is automatically biased into closed condition. The only way in which valve 22 may be opened is by means of the drive unit 42, and only when coupling 38 is energized. A pair of limit switches 44 and 46, respectively, are associated with valve 22 and operate as follows: limit switch 44 is closed only when valve disc 24 is in its fully closed position, that is, in a perfectly horizontal position, and switch 44 will open the instant that valve disc 24 leaves its completely closed position; limit switch 46 is open only when valve disc 24 is in its fully closed position and switch 46 closes the instant that disc 24 leaves its fully closed position.

The drive unit 42 for the safety butterfly valve may comprise a reversible electrical low speed motor energized from a separate power line 43, the operation of which is controlled by starter relays 48 and 50, respectively. In other words, the energization of starter relay 48 will close contacts 48a—48a' thereof and cause drive unit 42 to

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rotate in a direction to open the valve 22 and the energization of starter relay 50 will close contacts 50a—50a' thereof and cause drive unit 42 to rotate in a direction to close the valve 22. The drive unit 42 is of the type which remains in its last position until moved therefrom by the energization of either one of starter relays 48 and 50.

The drive unit 42 is also associated with three limit switches, namely limit switches 52, 54 and 56. Limit switch 56 is closed at all times, except when the drive unit is in the position it would be in if the amount of gas desired to be introduced into the stove were maximum, that is, when the drive unit is in position which will cause the valve disc 24 to be in its fully open position (90° from its fully closed position). Limit switch 52 is open only when the drive unit is in its zero or initial position corresponding to the position it would be in if the amount of gas desired to be introduced into the stove were zero. This limit 52 will be closed as soon as the drive unit is moved from its said zero or initial position thereof. Limit switch 54 is closed only when the drive unit is in its zero or initial position, and this switch 54 will be opened as soon as the drive unit is moved from said zero or initial position thereof.

A magnetic coupling relay 58 is provided. This relay 58 operates five sets of contacts, namely 58a—58a', 58b—58b', 58c—58c', 58d—58d' and 58e—58e'. Relay 58 is shown in FIG. 1 in its unenergized condition, and in such condition, it will be noted that contacts 58a—58a' thereof are closed while contacts 58b—58b', 58c—58c', 58d—58d' and 58e—58e' thereof are open. It will be understood that when relay 58 is energized (during the operation of the system), contacts 58a—58a' thereof will be open, while the other contacts thereof will be closed. A manually operated switch 60 controls four sets of contacts, namely contacts 60a—60a', 60b—60b', 60c—60c' and 60d—60d'. Switch 60 is a manually operated two-position switch for selectively placing the system under automatic or manual gas regulation control, as will be more fully explained hereafter. In the automatic position of switch 60, contacts 60a—60a' and 60b—60b' are closed while contacts 60c—60c' and 60d—60d' thereof are open. In the manual position (shown in FIG. 1) of switch 60, contacts 60a—60a' and 60b—60b' thereof are open, while contacts 60c—60c' and 60d—60d' thereof are closed. A pair of push button switches are also provided, namely, switches 62 and 64. These switches, as will more clearly be seen hereafter, are utilized during the manual operation of the system, wherein switch 62 is pushed to open the valve 22 and switch 64 is pushed to close said valves. For automatic gas regulation, there is provided an automatic gas volume regulator 66 which is interconnected in the circuitry, as shown in FIG. 1, the operation of which will be more fully explained hereafter. The gas volume regulator 66 may take any convenient form, not essential to this invention, such as an adjustable, two-way thermostatic controller having separate electrical outputs for the "fuel increase" and "fuel decrease" conditions. Such a device is disclosed in U.S. Patent No. 2,272,864. A signal lamp 68 is also provided, and is connected in the circuitry in such a way that as soon as the butterfly valve 22 is opened, the lamp will be lit so as to obtain a visual indication that gas is being introduced into the stove.

As previously stated, a fan 20 is used to feed air through the air main 18. A pressure gage 70 having contacts 70a—70a' is provided for air main 18. The contacts 70a—70a' in the pressure gage 70 are normally open during the operation of the system and are automatically closed only when the pressure in the air main 18 falls below a predetermined value set therefor, while pressure gage 70 has been shown in FIG. 1 as being of the manometer type, a centrifugal type switch responsive to the operation of the fan could equally well

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be utilized. The contacts 70a—70a' of switch 70 are in series with a relay 72 having one set of contacts 72a—72a', for reasons which will be fully explained hereafter. It will be noted at this time, however, that contacts 72a—72a' of relay 72 are normally closed when relay 72 is unenergized and are open when relay 72 is energized.

Air main 18 is also provided with a conventional combustion air regulating butterfly valve 74 which operates an associated position sensing switch 76 through a mechanical linkage, shown schematically as a dotted line in the drawings. Switch 76 is open only when air regulating valve 74 is completely closed, and this switch 76 is closed as soon as valve 74 is open.

A time delay relay 78 is interconnected with the other components as shown in FIG. 1, and controls a set of contacts 78a—78a'. When relay 78 is energized, it is operative to instantaneously close contacts 78a—78a' thereof, and these contacts remain closed for only a short adjustable period of time after which they automatically reopen, even though relay 78 is still energized. The reasons for the utilization of time delay relay 78 will be fully set forth hereafter.

The hot blast stove 10 is provided with a combustion chamber wall temperature control instrument 80, such as a pyrometer, which controls a set of contacts 80a—80a'. The control instrument 80 is responsive to the temperature of the chamber wall temperature and is operative to keep contacts 80a—80a' thereof closed at all times, except when the temperature of the combustion wall chamber drops below a predetermined temperature which is preferably set to be the ignition temperature of the gas. Contacts 80a—80a' of control instrument 80 are connected with the other parts of the circuitry, as shown in FIG. 1, for reasons which will be fully explained hereafter.

When a stove is to be changed from the "On Blast" condition to the "On Gas" condition, in which latter condition it will be heated, all the usual valves of the stove are operated in interlocked sequence starting with the closing of the hot blast valve, closing of the cold blast valve, and opening of the chimney valve. After the chimney valve has been fully opened, the burner shut-off valve 12 and the gas shut-off valve 14 are opened. As soon as the burner shut-off valve is fully opened, a limit switch 82, which is operated by valve 12 through a mechanical interconnection similar to that employed by valve 74, has contacts 82a—82a' thereof closed. The full opening of the burner shut-off valve is also operative to complete a circuit (not shown) to the fan which then becomes operative to force air into the air main 18. An apparatus for automatically operating the valves and fan in such interlocked sequence is fully disclosed in application Serial No. 682,913, filed September 9, 1957, now Patent No. 2,931,635, issued April 5, 1960. Said patent is assigned to the assignee hereof, and one of the joint inventors of said patent is also a joint inventor of this application. The interlocked sequence of operation of the valves as set forth above is for the purpose of explanation and does not form part of this invention.

A main disconnecting switch 84, connects the circuitry of FIG. 1 to power lines L1 and L2.

The operation of the system will now be described with reference to FIG. 1 by tracing through the entire circuitry through the various elements as the system is put into operation from its initial condition. FIG. 1 represents the components in the initial condition of the system corresponding to the condition of the system existing when the combination regulating and safety butterfly valve 22 is fully closed, the drive unit is in its initial or zero position, the burner shut off valve has not yet been fully opened, the wall temperature of the stove is below the predetermined value set for control instrument 80, the main distribution switch 84 has not yet been closed, all the relays

are in the unenergized condition, and the switch 60 is set for manual gas-regulating control. In such initial condition of the system, Chart A indicates the condition of all the contacts, switches, relays and the reason for such condition.

Chart A

Relay or switch	Contacts	Condition	Reason	Line location in Fig. 2
72-----		Unenergized	Fig. 1 shows all relays in unenergized condition.	a
70-----	70a—70a'	Closed	These contacts are closed when the pressure in the air main is below minimum, which is the condition of the system in Fig. 1, since it is shown at a time before the burner valve is fully opened, and therefore, before the fan has been rendered operative.	a
82-----	82a—82a'	Open	The system is shown before the burner shut-off valve is fully opened.	b
80-----	80a—80a'	do	The system is shown when the wall temperature is below the predetermined value set therefor.	b
76-----		do	The system is shown before the burner shut-off valve is fully opened, and therefore, before the air regulating butterfly valve has been opened.	b
72-----	72a—72a'	Closed	Relay 72 is shown in unenergized condition, in which contacts 72a—72a' thereof are closed.	b
58-----		Unenergized	All relays are shown unenergized.	b
58-----	58d—58d'	Open	Relay 58 is unenergized.	b
44-----		Closed	The system is shown with the combination gas regulating and safety butterfly valve fully closed, in which condition switch 44 is closed.	ba
54-----		do	The system is shown with drive unit in its initial or zero position, in which limit switch 54 is closed.	ba
78-----	78a—78a'	Open	Relay 78 is unenergized, in which condition contacts 78a—78a' thereof are open.	bb
78-----		Unenergized	All relays are shown unenergized.	c
58-----	58e—58e'	Open	Relay 58 is shown unenergized.	d
52-----		do	The drive unit is shown in its zero or initial position, in which limit switch 52 is open.	e
58-----	58a—58a'	Closed	Relay 58 is shown energized, in which condition contacts 58a—58a' thereof are closed.	e
50-----		Unenergized	All relays are shown unenergized.	e
58-----	58b—58b'	Open	Relay 58 is shown unenergized.	ea
64-----		do	Push button switch 64 is normally open.	ea
60-----	60c—60c'	Closed	Switch 60 is shown in the manual position, in which contacts 60c—60c' thereof are closed.	ea
60-----	60a—60a'	Open	Switch 60 is shown in the manual position, in which contacts 60a—60a' thereof are open.	eb
56-----		Closed	The drive unit is in its zero position in which limit switch 56 is closed.	f
58-----	58e—58e'	Open	Relay 58 is shown unenergized.	f
62-----		do	Push button switch 62 is normally open.	f
60-----	60d—60d'	Closed	Switch 60 is shown in the manual position, in which contacts 60d—60d' thereof are closed.	f
48-----		Unenergized	All relays are shown unenergized.	f
60-----	60b—60b'	Open	Switch 60 is shown in the manual position, in which contacts 60b—60b' thereof are open.	fa
46-----		do	The combination safety and regulating valve 22 is in fully closed position, in which limit switch 46 is open.	g

Before going into a full description of the operation of the system with reference to FIG. 1, reference is made to FIG. 2 which represents the identical elements shown in FIG. 1, but in a circuitry which is far simpler than FIG. 1 but is nevertheless the exact electrical equivalent thereof. For purposes of reference, each of the lines emanating from line L₂ in FIG. 2 has been identified by letters a, b, c, d, e, f and g, and the other lines branching off from these first referred to lines are identified by double letters, ba, bb, etc. The last column of Chart A above indicates the location of the particular element in FIG. 2.

The operation of the system will now be described. Referring now to FIG. 1, let us assume that the main distribution switch 84 is closed, that the wall temperature is now above the predetermined value therefor, and that the stove is ready to be heated, that is, the burner shut-off valve has been fully opened. Under these circumstances contacts 82a—82a' of switch 82 will be closed and contacts 80a—80a' of control instrument 80 will also be closed. As a result, a circuit is now completed from power line L₁ to power line L₂ as follows: Line L₁, line L₃, line L₄, closed switch 82, line L₅, closed contacts 80a—80a', L₆, relay 78, line L₇, Line L₈, line L₉, and line L₂ (the same circuit completion between L₁ and L₂ is also shown, more simply, in FIG. 2). The completion of this circuit, as just seen, energizes delay relay 78 and causes, for an adjustable short period of time, the closing of contacts 78a—78a', which are controlled by delay relay 78. The closing of contacts 78a—78a' completes another circuit from line L₁ to line L₂ as follows: Line L₁, switch 84, line L₃, line L₄, closed contacts 82a—82a', line L₅, closed contacts 80a—80a', line L₆, line L₁₀, closed contacts 78a—78a', normally closed contacts 72a—72a' of relay 72, line L₁₁, line L₁₂, closed limit switch 44 (this limit switch being closed at the initial conditions of the system, namely, when the valve disc 24 is in its fully closed condition), line L₁₃, closed switch 54 (this limit switch of drive unit 42 being closed when the drive unit is in its initial condition, corresponding to the fully closed condition of valve 22), line L₁₄, relay 58, line L₁₅, line L₈, line L₉, switch 84, and line L₂. The complete circuit just described between line L₁ and line L₂ is more easily seen, in FIG. 2, by just going down line b and line ba. Thus it is seen that relay 58 becomes energized.

The energization of relay 58, as described above, will affect its contacts as follows:

- (1) Contacts 58a—58a' (line e in FIG. 2), will open,
- (2) Contacts 58b—58b' (line ea in FIG. 2) will close,
- (3) Contacts 58c—58c' (line f in FIG. 2) will close,
- (4) Contacts 58d—58d' (line b in FIG. 2) will close,
- (5) Contacts 58e—58e' (line d in FIG. 2) will close.

The closing of contacts 58d—58d' permits relay 58 to remain energized regardless of what may subsequently happen to limit switches 44 and 54. This is due to the fact that contacts 58d—58d' are connected in parallel with the series connected switches 54 and 44, as seen in FIG. 1 and even more clearly in FIG. 2.

The closing of contacts 58e—58e' (as a result of the energization of relay 58) immediately causes the energization of magnetic coupling 38 since a complete circuit is established from line L₁ to line L₂, through magnetic coupling 38 as follows: Line L₁, switch 84, line L₃, L₄, closed switch 82, L₅, L₁₆, closed contacts 58e—58e', L₁₇, magnetic coupling 38, L₁₈, L₉, switch 84 and L₂. Thus it is seen that coupling 38 is now energized so that shaft 40 of the drive unit is now physically connected to the shaft 26 which mounts the valve disc 24 whereby the drive unit 42, when rotated, will cause the opening of valve 22.

At this time, it must be remembered that relay 78 will remain energized for only an adjustable period of time, and therefore, contacts 78a—78a' will remain closed, for only a short period of time. If the system is operating properly, the opening of the burner shut-off valve will have caused the immediate operation of the fan and the immediate opening of the air regulating valve 74. In such

case, switch 76 will be instantaneously closed. Switch 76, it will be noted, is connected by leads L_{19} and L_{20} in parallel with contacts $78a-78a'$. Accordingly, if the system is operating properly, there will be no interruption in the circuitry due to the reopening, after the adjustable delay, of contacts $78a-78a'$. On the other hand, in the event that something is wrong and the air regulating valve 74 has not begun to open, when the time delay of relay 78 has passed, the circuit to relay 58 is immediately interrupted to prevent the gas valve from being opened.

It will also be noted at this time that after the system is operating properly, as soon as the burner shut-off valve is completely open, the fan will be operated so that air under pressure will be introduced into the air main 18. Accordingly, contacts $70a-70a'$ of switch 70 will be open so as to maintain relay 72 de-energized, and contacts $72a-72a'$ closed. In this connection it will be noted that relay 72 is connected to switch 70 by means of lead L_{21} so that relay 72 can be energized only when switch 70 is closed, that is, when the pressure in air main 18 is below a predetermined value. Contacts $72a-72a'$ must be closed in order to keep the magnetic coupling relay 58 energized. Accordingly, if the pressure in the air main is not built up to a sufficient amount immediately for any reason, contacts $70a-70a'$ will close, thereby energizing relay 72 and opening contacts $72a-72a'$, and in that way immediately interrupting the energization of relay 58, to thereby prevent valve 22 from being opened.

Assuming that combustion air is being properly introduced into the stove, relay 58 will remain energized and such energized condition of relay 58, as previously indicated, has caused contacts $58e-58e'$ thereof (shown in line d in FIG. 2) to close, thereby energizing the magnetic coupling 38 to physically connect the drive unit 42 to the shaft 26 of the combination safety and regulating butterfly valve 22.

The system is now ready to permit the opening of the combination safety and regulating valve 22, and will first be described for manual operation in which, it will be remembered, switch 60 is in the manual position in which contacts $60a-60a'$ and $60b-60b'$ are open, while contacts $60c-60c'$ and $60d-60d'$ are closed.

To initiate the manual operation of the system for opening valve 22, push button 62 is manually closed. The manual closing of push button 62 is operative to complete a circuit to starter relay 48 as follows: Line L_1 , switch 84, line L_3 , line L_{22} , closed switch 56 (this switch being closed at all times except when the drive unit 42 has been moved to its maximum position), L_{23} , closed contacts $58c-58c'$ (these contacts having been closed as a result of the energized condition of magnetic coupling relay 58), L_{24} , L_{25} , closed push button switch 62, L_{26} , closed contacts $60d-60d'$, L_{27} , L_{28} , starter relay 48, L_{29} , L_{40} , L_9 , switch 84 and L_2 . The energization of the starter 48 can also be readily seen in FIG. 2 at line f . Thus it is seen that by closing push button 62, starter relay 48 is energized, which in turn causes the closing of contacts $48a-48a'$ thereof. The closing of contacts $48a-48a'$ as previously explained, causes drive unit 42 to rotate in a direction so as to open butterfly valve 22, to permit the admission of gas into the burner. The extent to which valve 22 is opened depends on the length of time the push button 62 is pushed. Under manual operation, the operator would have a visual indicator to look at and would push button 62 the desired length of time so as to open the valve 22 a correspondingly predetermined amount. When he has reached this amount, he will stop pushing switch 62 and the drive unit will remain in the position to which it has been moved, though the energization of the starter relay 48 has been interrupted. If thereafter the operator wishes to further open the valve 22, all he needs to do is to push button 62 for an additional period of time, as may be required.

At this time, it may be noted that under automatic

operation contacts $60b-60b'$ of switch 60 (line fa in FIG. 2) would be closed and contacts $60d-60d'$ of switch 60 (line f in FIG. 2) would be open. Under automatic operation, therefore, it will be noted that the starter relay 48 is in series with the automatic gas regulating device 66 in the circuit between L_1 and L_2 as follows: L_1 , switch 84, L_3 , L_{22} , switch 56, L_{23} , contacts $58c-58c'$, L_{24} , closed contacts $60b-60b'$, line L_{30} , automatic gas regulator 66, L_{31} , L_{28} , starter relay 48, L_{29} , L_{40} , switch 84, and L_2 . Accordingly, it is seen that when the system is under automatic control, it is the automatic regulator 66 which controls the energization of starter relay 48 instead of push button 62, and thereby automatically determines the extent to which valve 22 is to be opened.

It will be noted that the circuit which energizes starter relay 48, includes, in series, limit switch 56 and the latter must be closed to permit starter relay 48 to be energized. This limit switch is a safety device to prevent the drive unit 42 from being opened beyond a predetermined position corresponding to valve 22 being fully opened. More specifically, when the drive unit 42 reaches its position corresponding to the maximum opening of the valve 22, limit switch 56 automatically opens to instantaneously de-energize starter 48 and thereby prevents the further operation of the drive unit 42 in a direction to open the valve.

As soon as the drive unit 42 has been operated to open valve 22, limit switch 54 opens as does switch 44. As previously stated, the opening of these two switches does not affect the continued energization of coupling relay 58, since contacts $58d-58d'$ (in parallel with series-connected switches 44 and 54) are closed. It will also be noted that as soon as the drive unit moves to open the valve 22, limit switch 52 associated with drive unit 42 will close. Due to such closing of switch 52 after valve 22 has been opened, a circuit can be completed to starter relay 50 for closing the valve 22, if so desired, by pushing push button switch 64, under manual operation, as follows: Line L_1 , switch 84, L_3 , L_{22} , L_{32} , switch 52 (this switch is the one which is closed as soon as the drive unit has been moved from its zero position), L_{33} , contacts $58b-58b'$ (these are closed when coupling relay 58 is energized), L_{34} , L_{35} , push button switch 64, L_{36} , contacts $60c-60c'$ (closed under manual operation), L_{37} , L_{38} , L_{39} , starter relay 50, L_{40} , L_9 , switch 84, and L_2 (the same completed circuit is seen in FIG. 2). Valve 22 can also be closed automatically by means of the automatic gas regulator 66, when switch 60 is placed in the automatic position in which contacts $60a-60a'$ are closed and contacts $60c-60c'$ are open, the complete circuit being as follows: L_1 , switch 84, L_3 , L_{22} , L_{32} , limit switch 52, L_{33} , contacts $58b-58b'$, L_{34} , contacts $60a-60a'$, L_{41} , regulator 66, L_{42} , L_{38} , L_{39} , starter relay 50, L_{40} , L_9 , switch 84 and L_2 .

Thus it is seen that once valve 22 has been opened, the circuitry is in condition to permit the valve to be closed either manually, by closing push button 64, or automatically, by means of gas volume regulator 66. It will be noted that if, after valve 22 has been opened, push button 64 is continuously pushed so as to close valve 22, the starter relay 50 will remain energized only up to the point at which the valve 22 is restored to its fully closed position. This is due to the fact that as soon as valve 22 is restored to its fully closed position, limit switch 52 is automatically opened to interrupt the circuit to starter relay 50 and thereby prevent the further closing of valve 22. This therefore is seen to be a safety feature to prevent the drive unit from continuing to rotate the valve after it has reached its closed position, and thus prevent the breakage of any part of the system.

Whenever the combination gas regulating and safety valve 22 is opened, switch 46 is closed to complete a circuit through signal lamp 63 as follows: L_1 , switch 84, L_3 , L_4 , L_{43} , switch 46, L_{44} , signal lamp 63, L_{45} , L_9 , switch 84 and L_2 . Accordingly, signal lamp 63 is lit in order

to give a visual indication as soon as valve 22 begins to open to permit gas to be introduced into the burner and stove.

The normal operation of the system has been described, and according to such operation, it is seen so far that the valve 22 operates as a gas regulating valve to govern the amount of gas admitted into the stove. The safety aspect of the same valve will now be discussed so as to fully set forth the dual function of the valve 22, namely the function of being a regulating valve as well as a safety valve. Before proceeding with the disclosure of the safety aspect of the system, it will be noted that all the circuitry with all electric lead means has been completely described heretofore. It has been noted however that FIG. 2 shows the exact electrical equipment of the relatively complicated circuitry shown in FIG. 1. In view of the simplicity of FIG. 2 and the fact that the accuracy of the electrical equipment of FIG. 2 has been demonstrated, the further description of the safety aspect of the invention will be described in connection with FIG. 2.

Let us assume that after the system has been operating satisfactorily, there is a sudden power failure from any source whatsoever. As soon as such power failure occurs, the magnetic coupling 38 (which requires power to physically interconnect the drive unit with shaft 26 of the valve disc 24) is instantaneously de-energized to break the physical connection between the drive unit and the shaft 26. Shaft 26 being thus unconstrained at its end 36, the valve disc 24 is automatically and gravitationally biased into immediate closing position, due primarily to the counterweight 34. This of course will immediately interrupt the introduction of gas into the stove. The drive unit, however, though there has been an interruption of power, will remain in the position it was in at the time of the power failure, since, as previously explained, power must be supplied to the drive unit to move it in either direction. Due to the power failure, all relays which had been energized will of course be de-energized. One of such relays is relay 58. The de-energization of this relay 58, due to power failure, will immediately cause the closing of contacts 58a—58a' thereof. Also, since the drive unit is not in its zero or initial position, limit switch 52 is closed. Accordingly, when there is power failure, it will be noted that there is a complete circuit from power line L₁ to L₂ (through all the components in line e of FIG. 2), but such complete circuit is unenergized due to the power failure.

Due to the power failure the circuitry in lines a, b, c and d has been substantially restored to the initial conditions thereof in FIG. 2, with the exception of limit switch 54 (line ba) which is still open, such being due to the fact that the drive unit 42 has remained in the position it was in at the time of the power failure and has not been restored to its zero or initial position.

When, after repair, power has been restored to the system, and to lines L₁ and L₂, the first thing that happens immediately upon such restoration of power is for the circuit through line e to be energized. The energization of the circuit of line e will automatically cause the starter relay 50 to be energized, thereby causing movement of the drive unit in a direction toward its initial position. When the drive unit has reached its initial position, switch 52 (line e) will be open to stop the operation of the drive unit at the initial point. At the same time that the drive unit is restored to its initial position and switch 52 is open, the contacts of limit switch 54 (line ba) are closed. When this occurs, it will be noted that FIG. 2 is exactly in the position it was in at the beginning of the operation of the system, so that the system is ready to once more be operative to open the valve 22, in the same manner as previously described.

Accordingly, it is seen that in the event of power failure, the safety feature of valve 22 immediately goes into effect, namely the valve disc 24 immediately closes,

while the drive unit remains in its last position. When power is restored, the drive unit is automatically brought back to its initial position and only after the drive unit has so been brought back, is the system once more ready to be operated either manually or automatically for introducing gas into the stove.

In the event that after the system has been in operation, there is a failure of pressure in air main 18 caused by the inoperativeness of the fan or for any other reason, contacts 70a—70a' of switch 70 will immediately be closed to energize relay 72 (line a). This in turn will cause the immediate opening of contacts 72a—72a' of relay 72 (line b) to immediately interrupt the circuit to magnetic coupling relay 58 to thereby immediately de-energize the coupling and physically disconnect the shaft 26 from the drive unit. As previously explained, such break in the physical connection will immediately cause the valve disc 24 to be gravitationally biased to its closed position to prevent any further admission of gas into the stove.

Upon the de-energization of relay 58, contacts 58a—58a' thereof (line e) will be closed, and since the drive unit is not in its initial or zero position, the contacts of switch 52 (line e) are also closed. Accordingly, the circuit of line e is complete and the drive unit will be automatically restored to its initial position. The entire system is thus automatically placed into the initial position thereof so as to be ready to be placed in operation once more, as soon as the damage has been repaired.

Accordingly, it is seen that in the event of a failure of air pressure, for whatever reason, the valve disc 24 is immediately closed and the drive unit is restored to its initial position in order to place the system into readiness for satisfactory operation, after repair.

While the system of FIG. 1 has been described in connection with the utilization of an electrically operated magnetic coupling or clutch, it will be understood that other ways can be used to physically connect the shaft 40 of the drive unit with the shaft 26 of the valve 22. For example, instead of such magnetic coupling, a hydraulic coupling, an electro-hydraulic coupling or pneumatic coupling could equally well be used. In the event that a hydraulic or pneumatic coupling is used, it will of course be understood that the relay 58, when energized, will operate a solenoid valve which would open a bypass in the coupling cylinder for the hydraulic or pneumatic coupling and cause the actuation of a spring actuated clutch for physically interconnecting shaft 40 with shaft 36.

Referring now to FIG. 3, there is shown therein another embodiment of the system shown in FIG. 1. The embodiment of FIG. 3 is identical in almost every respect to the system of FIG. 1, except for the manner of operation of the drive unit. Instead of having the drive unit of FIG. 1, there is used instead a fluid drive unit of the hydraulic or pneumatic type, for example, supplied with operating pressure from fluid supply line 45 and which is operated by a pair of solenoid valves, namely 86 which is operative to move the drive unit in a direction for opening the valve 22, and solenoid 88 which is operative to move the drive unit in a direction for closing the valve 22. In all other respects, the system of FIG. 3 operates in exactly the same way, and accordingly, the circuitry shown in FIG. 4 is identical to the circuit shown in FIG. 2, except for the fact that the starter relays 48 and 50 of FIGS. 1 and 2 have been replaced by solenoid valves 86 and 88, respectively, in FIGS. 3 and 4. When using the solenoid valve as in FIGS. 3 and 4, the extreme positions of the drive unit corresponding to the zero position thereof and the fully opened position thereof, are automatically controlled by the piston itself. In this way, there is no possibility for the drive unit to be moved in one direction beyond the position thereof corresponding to the fully opened position of valve disc 24, and beyond

the initial or zero position thereof corresponding to the fully closed position of the valve disc 24. Accordingly, limit switches 52 and 56, formerly needed in FIGS. 1 and 2, are no longer needed in FIGS. 3 and 4, respectively. In all other respects, the circuit of FIG. 4 is identical to that of FIG. 2.

It will be recalled that the wall temperature control instrument 80, which controls the set of contacts 80a—80a', was incorporated in the system so that in the event that the wall temperature of the combustion chamber is below a predetermined value, contacts 80a—80a' will remain open and will prevent the entire system of FIG. 1 or FIG. 3 from being placed in operation. This was, of course, a safety feature to prevent gases from going into the stove if the temperature of the wall thereof was below the ignition temperature of the gas. In such event, though the burner shut-off valve might be fully opened, the stove would nevertheless not have gas and air fed thereto for combustion and heating purposes.

In order to remedy the above situation, there is provided an auxiliary burner and circuit which may be utilized in conjunction with the systems of FIGS. 1 and 3, which goes into effect only in the event that the wall temperature is below the predetermined value set for instrument 80. This auxiliary burner and circuitry is shown in FIG. 5.

Referring now to FIG. 5, it will be noted that there is provided an auxiliary burner 90 partly extending into an opening 92 in the wall of the stove 10. A pair of electrodes are provided to define a spark plug 94. Air is supplied to the auxiliary burner through line 96, the supply of which is controlled by a solenoid valve 98. The valve 98 is in turn controlled by relay 100. Similarly, gas is supplied to the auxiliary burner through line 102, the supply of which is controlled by a solenoid valve 104. The valve 104 is in turn controlled by relay 106. A high voltage is supplied to the spark plug 94 through line 108 in which there is provided an ignition coil 118. Line 103 is energized when contacts 110a—110a' of a spark plug relay 110, are closed. In addition, it will be noted that the wall temperature control instrument 80 is provided, in addition to the previously discussed contacts 80a—80a', with contacts 80b—80b', which are arranged to remain closed so long as the wall temperature of the combustion chamber is below the predetermined value set therefor. In other words, when contacts 80a—80a' of the wall temperature control instrument 80 are opened, then contacts 80b—80b' thereof will be closed, and vice versa. Finally, there is provided an auxiliary burner time delay relay 112 with which the components discussed above are electrically connected, as shown in FIG. 5. Delay relay 112 operates three sets of contacts, namely contacts 112a—112a', 112b—112b' and 112c—112c'. Delay relay 112 operates in the following fashion: when it is energized, it will immediately cause the closing of all of its contacts. When it is de-energized, however, its contacts will remain closed for an adjustable predetermined period of time, and then reopen.

An auxiliary burner disconnecting switch 114 is provided to interconnect the circuitry of FIG. 5 with power lines L₁ and L₂, respectively.

The actual operation of the auxiliary device will now be described with particular reference to FIG. 5. It should be noted, however, that FIG. 6 represents the electrical equivalent of the circuitry shown in FIG. 5 and may also be referred to in connection with the discussion of the device of FIG. 5.

Referring now to FIG. 5, it will be noted that when the stove 10 is ready to go "On Gas," the burner shut-off valve will be fully opened, thereby closing contacts 82a—83a' of limit switch 82 (exactly in the same manner in which these contacts operate in FIGS. 1 through 4). In the event that at such time the wall temperature is below the predetermined value set therefor, the systems

of FIGS. 1-2 and FIGS. 3-4 are incapable of being put into operation. In the circuit of FIG. 5, however, in the event that the wall temperature is below the predetermined value set therefor, contacts 80b—80b' of control instrument 80 will be closed to immediately complete a circuit to delay relay 112 as follows: L₁', switch 114, L₃', L₄', closed contacts 82a—82a', L₅', L₇', closed contacts 80b—80b', L₈', delay relay 112, L₁₀', L₉', switch 114, and L₂'. In this way, as soon as the burner shut-off valve is fully opened, delay relay 112 is energized and the same immediately causes the closing of contacts 112a—112a', 112b—112b' and 112c and 112c' thereof. The closing of contacts 112b—112b' causes the immediate energization of the gas solenoid valve relay 106 as follows: L₁', switch 114, L₃', L₄', contacts 82a—82a', L₅', L₁₁', closed contacts 112b—112b', L₁₂', relay 106, L₁₃', L₉', switch 114, and L₂'. Such energization of gas relay 106 causes the opening of solenoid gas valve 104 to permit gas to be admitted into the auxiliary burner 90. The closing of contacts 112c—112c' as a result of the previously described energization of delay relay 112 will immediately cause the energization of air solenoid valve relay 100 as follows: L₁', switch 114, L₃', L₄', contacts 82a—82a', L₅', L₁₁', contacts 112c—112c', L₁₄', air valve relay 100, L₁₅', L₉', switch 114, and L₂'. Such energization of air valve relay 100 causes the immediate opening of air solenoid valve 98, to permit air to be admitted into the auxiliary burner 90. The closing of contacts 112a—112a', as a result of the previously described energization of delay relay 112, will cause the immediate energization of spark plug relay 110 as follows: L₁', switch 114, L₃', L₄', contacts 82a—82a', L₅', L₁₁', contacts 112a—112a', L₁₆', spark plug relay 110, L₁₀', L₉', switch 114, and L₂'. Such energization of spark plug relay 110, causes the closing of contacts 110a—110a' thereof which, in turn, completes a circuit from the high voltage lines (shown by heavy lines in FIG. 5), through ignition coil 118 and thereby provides a spark to the spark plug 94 for igniting the gas-air mixture coming into the auxiliary burner.

In this way, combustion of the gas-air mixture will take place for heating the stove wall. When sufficient mixture has been burned, the wall temperature of the stove will go up and reach the predetermined value set for the wall temperature control instrument 80. This will cause contacts 80a—80a' to be closed and contacts 80b—80b' to be opened. The closing of contacts 80a—80a' of control instrument 80 will immediately put the system of FIGS. 1-2 or FIGS. 3-4 in operation, as previously described. The opening of contacts 80b—80b' of control instrument 80 will interrupt the complete circuit to delay relay 112, and de-energize the latter. As previously stated, the de-energization of delay relay 112 will cause contacts 112a—112a', 112b—112b' and 112c—112c' thereof to reopen only after a predetermined adjustable period of time. During this period of time, both the system of FIGS. 1 and 2 and the auxiliary burner of FIGS. 5 and 6 will be in operation. This is a safety feature which will make sure that the gas and air first entering the stove from the system of FIGS. 1-2 or FIGS. 3-4 will be ignited by the spark plug 94, and thus avoid any risk of explosion. After the expiration of the short adjustable period of time of delay relay 112, contacts 112a—112a', 112b—112b' and 112c—112c' thereof will open to shut off the gas and air supplied to the auxiliary burner and to interrupt the power to the spark plug.

It is thus seen that the system described in connection with FIGS. 5 and 6 constitutes an auxiliary burner which can be used in connection with the systems of FIG. 1 and FIG. 3 to impart a greater measure of safety thereto. More specifically, the auxiliary burner feature of FIGS. 5 and 6 will insure immediate spark ignited auxiliary combustion in a stove which is to go "On Gas," when the

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wall temperature of such stove is below the predetermined value therefor at which gas and air will be introduced therein in the normal fashion, and such auxiliary combustion will be maintained until after the wall temperature has been raised to said predetermined value.

While we have shown and described the preferred embodiments of our invention, it will be understood that the invention may be embodied otherwise than as herein specifically illustrated or described, and that in the illustrated embodiment certain changes in the details of construction and in the form and arrangement of parts may be made without departing from the underlying idea or principles of this invention within the scope of the appended claims.

Having thus described our invention, what we claim and desire to secure by Letters Patent, is:

1. In a hot blast stove adapted to be heated and to supply hot blast to a blast furnace; gas conduit means for introducing gas into said stove, air conduit means for introducing air into said stove, valve means disposed in said gas conduit means and adapted to be adjustably opened for regulating the volume of gas introduced into said stove, electrically operated means adapted to be operatively connected to said valve means for controlling the extent of opening and closing of the latter, and means for automatically closing said gas volume regulating valve means in response to the failure of air being introduced into the stove.

2. In a hot blast stove adapted to be heated and to supply hot blast to a blast furnace; gas conduit means for introducing gas into said stove, air conduit means for introducing air into said stove, valve means disposed in said gas conduit means and adapted to be adjustably opened for regulating the volume of gas introduced into said stove, said valve means comprising a valve disc mounted in said gas conduit means and normally biased into a conduit closing position thereof, drive means for said valve means, means for operatively connecting said drive means to said valve disc for moving and maintaining the latter in a selected one of a plurality of positions different from the normally biased closed position thereof, and means for automatically rendering said connecting means inoperative in response to the failure of air being introduced into the stove, whereby said valve disc is automatically biased into said closed position thereof.

3. In a hot blast stove adapted to be heated and to supply hot blast to a blast furnace; gas conduit means for introducing gas into said stove, air conduit means for introducing air into said stove, valve means disposed in said gas conduit means and adapted to be adjustably opened for regulating the volume of gas introduced into said stove, said valve means comprising a valve disc mounted in said gas conduit means and normally biased into a conduit closing position thereof, drive means for said valve means, means for operatively connecting said drive means to said valve disc for moving and maintaining the latter in a selected one of a plurality of positions different from the normally biased closed position thereof, means for automatically rendering said connecting means inoperative in response to the failure of air being introduced into the stove, whereby said valve disc is automatically biased into said closed position thereof, and means for preventing said valve means from opening unless the combustion chamber temperature of said stove is above a predetermined value.

4. In a hot blast stove adapted to be heated and to supply hot blast to a blast furnace; gas conduit means for introducing gas into said stove, air conduit means for introducing air into said stove, valve means disposed in said gas conduit means and adapted to be adjustably opened for regulating the volume of gas introduced into said stove, valve means disposed in said air conduit means for regulating the amount of air introduced into said

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stove, electrically operated means adapted to be operatively connected to said gas volume regulating valve means for selectively and adjustably opening and closing the latter, means for automatically closing said gas volume regulating valve means in direct response to a failure of electrical power, and means for automatically closing said gas volume regulating valve means in response to the failure of said air regulating valve means to open a predetermined period of time after said gas regulating valve means has been opened.

5. In a hot blast stove adapted to be heated and to supply hot blast to a blast furnace; gas conduit means for introducing gas into said stove, air conduit means for introducing air into said stove, valve means disposed in said gas conduit means and adapted to be adjustably opened for regulating the volume of gas introduced into said stove, means for introducing air into said air conduit means, said valve means comprising a valve disc mounted in said gas conduit means and normally biased into a conduit closing position thereof, drive means for said valve means, electrically controlled means for operatively connecting said drive means to said valve disc for moving and maintaining the latter in a selected one of a plurality of positions different from the normally biased closed position thereof, and means for automatically rendering said connecting means inoperative in response to the failure of electrical power, whereby said valve disc is automatically biased into said closed position thereof, valve means disposed in said air conduit means for regulating the amount of air introduced into said stove, and means for automatically closing said gas regulating valve means in response to the failure of said air regulating valve means to open a predetermined period of time after said gas regulating valve means has been opened.

6. In a hot blast stove adapted to be heated and to supply hot blast to a blast furnace; gas conduit means for introducing gas into said stove, air conduit means for introducing air into said stove, valve means disposed in said gas conduit means and adapted to be adjustably opened for regulating the volume of gas introduced into said stove, means for introducing air into said air conduit means, said valve means comprising a valve disc mounted in said gas conduit means and normally biased into a conduit closing position thereof, drive means for said valve means, electrically controlled means operative when energized to connect said drive means to said valve disc for moving and maintaining the latter in a selected one of a plurality of positions different from the normally biased closed position thereof, whereby upon electrical power failure said electrically controlled connecting means becomes automatically de-energized and disconnects said drive means from said valve disc for causing the latter to be automatically biased to its conduit closing position thereof, means for de-energizing said electrically controlled connecting means when the pressure of the air in the air conduit falls below a predetermined value set therefor, and means for preventing said valve disc from opening unless the combustion chamber temperature of said stove is above a predetermined value.

7. In a hot blast stove adapted to be heated and to supply hot blast to a blast furnace; gas conduit means for introducing gas into said stove, air conduit means for introducing air into said stove, valve means disposed in said gas conduit means and adapted to be adjustably opened for regulating the volume of gas introduced into said stove, said valve means comprising a valve disc mounted in said gas conduit means and normally biased into a conduit closing position thereof, drive means for said valve means, means for operatively connecting said drive means to said valve disc for moving and maintaining the latter in a selected one of a plurality of positions different from the normally biased closed position thereof, and means for automatically rendering said connecting means inoperative in response to the failure of air being introduced into the stove, whereby said valve disc is automatically biased

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into said closed position thereof, said drive means being operated by a pair of solenoid valves and having a limited piston displacement between two positions corresponding to the fully closed and fully opened positions, respectively, of the valve disc.

8. In a hot blast stove adapted to be heated and to supply hot blast to a blast furnace; gas conduit means for introducing gas into said stove, air conduit means for introducing air into said stove, valve means disposed in said gas conduit means and adapted to be adjustably opened for regulating the volume of gas introduced into said stove, means for introducing air into said air conduit means, said valve means comprising a valve disc mounted in said gas conduit means and normally biased into a conduit closing position thereof, drive means for said valve means, electrically controlled means operative when energized to connect said drive means to said valve disc for moving and maintaining the latter in a selected one of a plurality of positions different from the normally biased closed position thereof, whereby upon electrical power failure said electrically controlled connecting means becomes automatically de-energized and disconnects said drive means from said valve disc for causing the latter to be automatically biased to its conduit closing position thereof, means for de-energizing said electrically controlled connecting means when the pressure of the air in the air conduit falls below a predetermined value set therefor, and limiting means for preventing said drive unit from causing said valve disc to move beyond the fully closed and fully opened positions thereof, respectively.

9. In a hot blast stove adapted to be heated and to supply hot blast to a blast furnace; gas conduit means for introducing gas into said stove, air conduit means for introducing air into said stove, valve means disposed in said gas conduit means and adapted to be adjustably opened for regulating the volume of gas introduced into said stove, means for introducing air into said air conduit means, said valve means comprising a valve disc mounted in said gas conduit means and normally biased into a conduit closing position thereof, drive means for said valve means, electrically controlled means operative when energized to connect said drive means to said valve disc for moving and maintaining the latter in a selected one of a plurality of positions different from the normally biased closed position thereof, whereby upon electrical power failure said electrically controlled connecting means becomes automatically de-energized and disconnects said drive means from said valve disc for causing the latter to be automatically biased to its conduit closing position thereof, and means for preventing the energization of said electrically controlled connecting means when said valve disc is in the closed position thereof and said drive means is in a position thereof different from that which corresponds to the closed position of said valve disc.

10. In a hot blast stove adapted to be heated and to supply hot blast to a blast furnace; gas conduit means for introducing gas into said stove, air conduit means for introducing air into said stove, valve means disposed in said gas conduit means and adapted to be adjustably opened for regulating the volume of gas introduced into said stove, means for introducing air into said air conduit means, said valve means comprising a valve disc mounted in said gas conduit means and normally biased into a conduit closing position thereof, drive means for said valve means, electrically controlled means operative when energized to connect said drive means to said valve disc for moving and maintaining the latter in a selected one of a plurality of positions different from the normally biased closed position thereof, whereby upon electrical power failure said electrically controlled connecting means becomes automatically de-energized and disconnects said drive means from said valve disc for causing the latter to be automatically biased to its conduit closing position thereof, means for de-energizing said electrically controlled connecting means when the pressure of the air in the air conduit

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falls below a predetermined value set therefor, and means for preventing the energization of said electrically controlled connecting means when said valve disc is in the closed position thereof and said drive means is in a position thereof different from that which corresponds to the closed position of said valve disc.

11. In a hot blast stove adapted to be heated and to supply hot blast to a blast furnace; gas conduit means for introducing gas into said stove, air conduit means for introducing air into said stove, valve means disposed in said gas conduit means and adapted to be adjustably opened for regulating the volume of gas introduced into said stove, means for automatically closing said gas volume regulating valve means in response to the failure of air being introduced into the stove, means for preventing said valve means from opening unless the combustion chamber temperature of said stove is above a predetermined value, an auxiliary burner for said stove provided with means for supplying a gas air mixture thereto and also provided with means for igniting said mixture, and means for placing said auxiliary burner in operation only when the combustion chamber temperature of said stove is below said predetermined value, for heating and raising the temperature of said chamber.

12. In a hot blast stove adapted to be heated and to supply hot blast to a blast furnace; gas conduit means for introducing gas into said stove, air conduit means for introducing air into said stove, valve means disposed in said gas conduit means and adapted to be adjustably opened for regulating the volume of gas introduced into said stove, means for automatically closing said gas regulating valve means in response to the failure of air being introduced into the stove, means for preventing said valve means from opening unless the combustion chamber temperature of said stove is above a predetermined value, an auxiliary burner for said stove provided with means for supplying a gas air mixture thereto and also provided with means for igniting said mixture, means for placing said auxiliary burner in operation only when the combustion chamber temperature of said stove is below said predetermined value, for heating and raising the temperature of said chamber, and means for maintaining said auxiliary burner in operation for a short adjustable period of time after said combustion chamber has reached said predetermined value.

13. In a hot blast stove adapted to be heated and to supply hot blast to a blast furnace; gas conduit means for introducing gas into said stove, air conduit means for introducing air into said stove, valve means disposed in said gas conduit means and adapted to be adjustably opened for regulating the volume of gas introduced into said stove, means for introducing air into said air conduit means, said valve means comprising a valve disc mounted in said gas conduit means and normally biased into a conduit closing position thereof, drive means for said valve means, electrically controlled means operative when energized to connect said drive means to said valve disc for moving and maintaining the latter in a selected one of a plurality of positions different from the normally biased closed position thereof, whereby upon electrical power failure said electrically controlled connecting means becomes automatically de-energized and disconnects said drive means from said valve disc for causing the latter to be automatically biased to its conduit closing position thereof, means for de-energizing said electrically controlled connecting means when the pressure of the air in the air conduit falls below a predetermined value set therefor, means for preventing said valve disc from opening unless the combustion chamber temperature of said stove is above a predetermined value, an auxiliary burner for said stove provided with means for supplying a gas air mixture thereto and also provided with means for igniting said mixture, and means for placing said auxiliary burner in operation only when the combustion chamber tempera-

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ture of said stove is below said predetermined value, for heating and raising the temperature of said chamber.

14. In a hot blast stove adapted to be heated and to supply hot blast to a blast furnace; gas conduit means for introducing gas into said stove, air conduit means for introducing air into said stove, valve means disposed in said gas conduit means and adapted to be adjustably opened for regulating the volume of gas introduced into said stove, means for introducing air into said air conduit means, said valve means comprising a valve disc mounted in said gas conduit means and normally biased into a conduit closing position thereof, drive means for said valve means, electrically controlled means operative when energized to connect said drive means to said valve disc for moving and maintaining the latter in a selected one of a plurality of positions different from the normally biased closed position thereof, whereby upon electrical power failure said electrically controlled connecting means becomes automatically de-energized and disconnects said drive means from said valve disc for causing the latter to be automatically biased to its conduit closing position thereof, means for de-energizing said electrically controlled connecting means when the pressure of the air in the air conduit falls below a predetermined value set therefor, means for preventing said valve disc from opening unless the combustion chamber temperature of said stove is above a predetermined value, an auxiliary burner for

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said stove provided with means for supplying a gas air mixture thereto and also provided with means for igniting said mixture, means for placing said auxiliary burner in operation only when the combustion chamber temperature of said stove is below said predetermined value, for heating and raising the temperature of said chamber, and means for maintaining said auxiliary burner in operation for a short adjustable period of time after said combustion chamber has reached said predetermined value.

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2,916,022	Arant	Dec. 8, 1959
3,007,490	Passmore	Nov. 7, 1961
3,039,522	Scholl	June 19, 1962